Notice No.6

Rules and Regulations for the Classification of Ships, July 2022

The status of this Rule set is amended as shown and is now to be read in conjunction with this and prior Notices. Any corrigenda included in the Notice are effective immediately.

Please note that corrigenda amends to paragraphs, Tables and Figures are not shown in their entirety.

Issue date: March 2023

Amendments to	Effective date	IACS/IMO implementation (if applicable)
Part 1, Chapter 2, Section 2	1 July 2023	N/A
Part 5, Chapter 24, Sections 1, 2, 3, 5, 6, 7 8 & 13	1 July 2023	N/A

Part 1, Chapter 2
Classification Regulations

■ *Section 2*
Characters of classification and class notations

2.5 Class notations (machinery special features)

2.5.9 The following notation associated with the Emissions Abatement Carbon Capture and Storage system may be assigned as considered appropriate by the Classification Committee:

EACCS () This class notation will be assigned where the Emissions Abatement Carbon Capture and Storage system has been designed, constructed, arranged, installed and tested in accordance with LR's Rules and Regulations (*see Pt 5, Ch 24, 1.2 Class notation and descriptive note 1.2.8* to *Pt 5, Ch 24, 1.2 Class notation and descriptive note 1.2.10* for more information). Application of the **EACCS** notation does not infer that the installation will meet the Statutory Requirements for emissions regulation. This notation is to be supplemented by additional associated characters depending on the carbon capture application (*see Pt 5, Ch 24, 1.2 Class notation and descriptive note 1.2.8* to *Pt 5, Ch 24, 1.2 Class notation and descriptive note 1.2.10* for more information).

Existing paragraph 2.5.9 has been renumbered 2.5.10.

2.8 Descriptive notes

2.8.10 **READY (EACCS())** Ships complying with particular aspects of these Rules may be eligible for assignment of LR's emissions abatement Carbon Capture and Storage READY descriptive note, **READY (EACCS)**. *See Pt 5, Ch 24, 1.2 Class notation and descriptive note 1.2.8* to *Pt 5, Ch 24, 1.2 Class notation and descriptive note 1.2.10* for more information. If a ship has been assigned the **EACCS ()** notation then it will not be eligible for the **READY (EACCS())** descriptive note.

This descriptive note will be assigned to ships with the extension of one or more of the relevant associated characters shown in brackets, detailing the aspects of design and construction that are prepared for installation of emissions abatement plant for combustion machinery in accordance with relevant LR Rules and Regulations (*see Pt 5, Ch 24, 1.2 Class notation and descriptive note 1.2.8* to *Pt 5, Ch 24, 1.2 Class notation and descriptive note 1.2.10* for more information).

Existing paragraphs 2.8.10 to 2.8.12 have been renumbered 2.8.11 to 2.8.13.

Part 5, Chapter 24
Emissions Abatement Plant for Combustion Machinery and other Machinery and Equipment

Section 1
General

1.1 Scope

(Part only shown)

1.1.1 The requirements of this Chapter apply to machinery and equipment fitted to combustion machinery, other machinery and equipment in order to reduce operational SO_x, NO_x and CO_2 emissions ~~produced by the combustion of fuel~~. Such machinery and equipment is hereinafter referred to as emissions abatement plant.

The requirements are intended to ensure that the emissions abatement plant is safe to operate and maintain and, additionally, where the combustion machinery, other machinery and equipment provides power for essential services, that failure of the emissions abatement plant does not result in an unacceptable loss or degradation of those essential services.

The requirements are applicable to emissions abatement plant making use of both primary techniques, which reduce emissions by controlling the combustion process or removing pollutants prior to combustion, e.g. Exhaust Gas Recirculation (EGR), and to secondary emissions abatement techniques which reduce emissions from the exhaust gas after combustion, e.g. scrubbers, ~~and~~ Selective Catalytic Reduction (SCR) and Carbon Capture scrubbers. Emissions abatement plant making use of primary techniques is also to satisfy the applicable requirements of *Pt 5, Ch 2 Reciprocating Internal Combustion Engines* (~~*See*~~ *see Pt 5, Ch 2, 1.2 Scope 1.2.4*).

1.2 Class notation and descriptive note

1.2.8 Ships complying with the relevant carbon emissions abatement plant requirements of this Chapter will be eligible for assignment of the **EACCS(xx,yy)** machinery notation. This notation is to be supplemented by one or more of the following associated characters depending on the carbon capture application:

EACCS(xx), where 'xx' identifies the type of technology. With reference to 'xx', the following identifiers are used:

(Amine) Chemical Absorption -Amine-based chemical solvent;
(Mineral) Mineral carbonation(Calcium looping);
(Fuel cell) Methane reforming and Molten carbonate Fuel cell;
(Membrane) Membrane separation;
(Cryogenic) Cryogenic separation;
(TCD) Thermo-Catalytic Decomposition process;

EACCS(yy), where 'yy' identifies the type of fuel. With reference to 'yy', the following identifiers are used:

LFFO Fuel oil with a flashpoint between 52°C and 60°C;
MDO/MGO (Diesel/Gas Oil, ISO 8217 grades DMX through DMB);
LFO (Light Fuel Oil, ISO 8217 grades RMA through RMD);
HFO (Heavy Fuel Oil, ISO 8217 grades RME through RMK);
VLSFO/ULSFO (ISO 8217 grades DMX through DMB, RMA through RMD and RME through RMK);
NG Natural gas;
EG Ethane gas;
PG Petroleum gas (considered to include pure propane or butane or any mixture of the two);
ML Methyl alcohol (methanol);
EL Ethyl alcohol (ethanol).

The **EACCS()** notation indicates that the carbon emissions abatement plant has been designed, constructed, arranged, installed and tested in accordance with LR's Rules and Regulations. Application of the **EACCS()** notation does not infer that the installation meets applicable statutory emissions regulations.

1.2.9 **READY (EACCS())** Ships complying with particular aspects of these Rules may be eligible for assignment of LR's emissions abatement Carbon Capture and Storage READY descriptive note, **READY (EACCS(xx,yy,z))**, where 'xx' identifies the type of technology, 'yy' identifies the type of fuel (consistent with the **EACCS** notation) and 'z' identifies the particular aspects which have been approved or approved and installed. This descriptive note may be assigned when aspects of design and construction are prepared for installation of carbon emissions abatement plant for machinery and equipment.

This descriptive note is not an LR class notation and is provided solely for information.

This descriptive note will be assigned to ships with the extension of one or more of the following associated characters shown in brackets, detailing the aspects of design and construction that are prepared for installation of emissions abatement plant for machinery and equipment in accordance with LR's Rules and Regulations in force on the date of 'contract for construction':

With reference to 'z', the following identifiers are used:

A Approval in Principle. The preliminary assessment and design including arrangement on board of the emissions abatement Carbon Capture and Storage system has been approved in principle.

S Structural Reinforcement Installed. Enhanced structural reinforcement using appropriate materials to support the proposed storage tank has been installed in accordance with an approved design and surveyed accordingly.

T Tank Installed. The storage tank(s) needed for the operation of carbon capture and storage plant have been built under survey and installed in accordance with an approved design and surveyed accordingly.

P Piping, Loading and Un-loading Manifolds Installed. Piping and equipment associated with the emissions abatement Carbon Capture and Storage system (e.g. pipes, pumps, valves, processing equipment, etc.) from the bunker/un-loading manifold to the carbon capture equipment, bunkering stations structural arrangements and associated access arrangements as applicable, and pipe routings, have been installed in accordance with an approved design and surveyed accordingly.

Application of the **READY (EACCS())** descriptive note does not infer that the proposed installation will meet the Statutory Requirements for emissions regulation.

1.2.10 The following are to be submitted to achieve the **READY (EACCS)** descriptive note with applicable associated characters:

(a) **For the qualifier A '**Approval in Principle'

- Vessel general arrangement;
- General arrangement of carbon emissions abatement plant illustrating the locations of carbon emissions abatement machinery and tanks with respect to machinery, control and service spaces;
- System arrangement (showing necessary modifications for installation of the proposed carbon emissions abatement system);
- Process Flow Diagrams (PFDs) and description of system, Piping and Instrumentation Diagrams (P&IDs) and Piping Routings (as available). This is to include all pipework and equipment from the bunker connection through to the emissions abatement plant;
- Hazardous area plan;
- Material Safety Data Sheet for Chemical, as applicable (both initial loaded and after usage);
- Arrangement and capacity of tanks for storage of CO_2, chemicals, sludge and residue as applicable and necessary;
- Information on the operational requirements of the proposed carbon emissions abatement plant with respect to sea water and electricity demand and additional chemical requirements as applicable;
- Electrical and control system requirements, including details of how the proposed system is to be incorporated into the vessel's electrical system;
- Preliminary studies for vessel Load Line and stability, taking the proposed carbon emissions abatement plant installation into account;
- Risk-based studies – the risk-based studies are to be undertaken in accordance with LR's ShipRight Procedure *Risk Based Certification (RBC)*, *see Pt 5, Ch 24, 13.2 Risk assessment and Risk Based Certification (RBC)*. The RBC-1 (Design and Safety Statement) and RBC-2 (Risk Assessment) stages are required.

(b) **For the qualifier S** 'Structural Reinforcement Fitted and Installed'

- Full details of the structural reinforcement required to support the proposed system and storage tank of carbon emissions abatement plant are to be submitted as necessary. This shall include details of the proposed storage tank capacity, plant type, size, location and loadings (dynamic and static) to allow verification of the submitted structural design and calculations for the plant support arrangements.

(c) **For the qualifier T '**Tank installed'

- Plans and information required for the **READY (EACCS(S))** descriptive note;
- Structural plans for the tanks to be installed, and any additional support arrangements where necessary for independent tanks, in accordance with *Pt 3, Ch 1, 2 Direct calculations*;
- Full details of the materials proposed for construction of the tank(s);
- Details of the flammability, toxicity, corrosivity and reactivity of any chemicals to be stored in the tanks, as applicable (both initial loaded and after usage);
- Details of air and sounding pipes to tanks containing chemicals, substances and effluent;
- Details of arrangements for loading, storage, transfer and disposal of chemicals, by-products or waste products. This is to include allowable maximum and minimum storage temperatures for substances which are sensitive to temperature;
- Detailed design of tank, pressure relief arrangement and isolation valve(s);
- P&ID for all piping integral to the tank (applicable to Type C tanks);
- Hazardous area plan for tank arrangements and associated ventilation, including details of electrical equipment to be installed in the identified hazardous areas;
- Risk assessment of the tank design and arrangement to the extent required for RBC.

(d) **For the qualifier P '**Piping, Loading and Un-loading Manifolds Installed'

- Process Flow Diagrams (PFDs), Piping and Instrumentation Diagrams (P&IDs) and Piping Routings. This is to include all pipework and equipment from the bunker connection through to the emissions abatement plant;
- Location and associated hazardous area assessment, including details of electrical equipment to be installed in the identified hazardous areas;
- Details of all piping systems, including details of piping and associated components, design pressures, temperatures, applicable external loads, insulation, and drip trays;

- Risk assessment of the piping design and arrangement to the extent required for RBC.

Section 2
Functional requirements

2.1 Functional requirements of emissions abatement plant

2.1.1 Emissions abatement plant is to be capable of operating at the stated maximum operating limits of the combustion machinery, other machinery and equipment to which it is connected. Where the machinery installation is configured such that it is not intended to operate all the combustion machinery connected to the emissions abatement plant simultaneously in normal operating conditions, this will be subject to special consideration and supported by the submission required by *Pt 5, Ch 24, 3.1 General 3.1.2*.

2.1.4 Where the emissions abatement plant is connected to combustion machinery, other machinery and equipment providing power for essential services, failure of, or the inability to operate, the emissions abatement plant is not to prevent the combustion machinery, other machinery and equipment from delivering sufficient power to those essential services so as to ensure the safe operation of the ship.

2.1.5 Any discharges to water and air from the emissions abatement plant are to be in accordance with the requirements of National and International Regulations, as applicable.

Section 3
Information to be submitted

3.1 General

3.1.3 Where emissions abatement plant makes use of more than one abatement technique, e.g. separate means for reducing NO_x ~~and~~, SO_x and CO_2, details demonstrating their compatibility with the combustion machinery, other machinery and equipment and with each other are to be provided.

3.1.6 Details of the hazards associated with operation and maintenance and reasonably foreseeable failure of the emissions abatement plant and the means by which they are mitigated in accordance with the requirements given in *Pt 5, Ch 24, 6 Mechanical equipment and components*. The details of impact on the operation of essential services due to failure of the emissions abatement plant and proposed mitigation measures are to be submitted.

3.1.9 Testing procedures for installation and commissioning trials of emissions abatement plant.

3.2 Materials and hull construction

3.2.1 Details of the materials proposed for all types of construction of emissions abatement plant.

3.3 Chemical substances

3.3.1 Details of the flammability, toxicity, asphyxiation, corrosivity and reactivity of any chemicals used, together with details of any exothermic and hazardous reactions, particularly with regard to sea water. This is to include effluent and sludge associated with emissions abatement plant as applicable.

3.3.2 General arrangement of spaces where asphyxiation, toxic or flammable liquids, gases, dusts or vapours are stored or may accumulate, indicating the hatches and other access openings.

Section 5
Hull construction

5.1 General

5.1.11 In general scrubber towers are to be enclosed in machinery casings complying with *Pt 3 Ch 8, 2 Scantlings of erections other than forecastles*. Where this is not the case and items of a scrubber tower penetrate the weather deck and are intended to constitute the structural barrier to prevent the ingress of water to spaces below the freeboard deck, their structural strength is to be equivalent to the Rule requirements for deck or bulkhead as appropriate.

5.1.12 Support arrangements for scrubber towers and portable tanks are to comply with *Pt 3 Ch 9, 9 Strengthening for machinery on deck.*

5.1.13 Fixed access is to be provided for inspection and maintenance of mountings, fittings, controls and pressure-relief devices.

Section 6
Mechanical equipment and components

6.1 General

6.1.9 The exhaust systems of emissions abatement plant associated with internal combustion engines are to comply with the requirements of *Pt 5, Ch 2, 8.3 Exhaust systems*.

6.1.10 Emissions abatement plant associated with fuel cells is to comply with the requirements of *Pt 5, Ch 26 Fuel Cell Power Installations*.

6.1.11 Mounting arrangements are to take account of forces and moments generated at the supports. Mounting arrangements are also to take account of thermal expansion and contraction. Accelerations due to ship motion caused by waves shall be considered for all equipment.

6.1.12 Portable tanks shall be secured to the deck while connected to the ship systems. The arrangement for fixing the tanks shall be designed for the maximum expected static and dynamic inclinations, as well as the maximum expected values of acceleration, taking into account the ship characteristics and the position of the tanks.

Section 7
Pumping and Piping

7.1 General

7.1.13 Overboard discharge connections from scrubbers are to be positioned below the lowest operating waterline and are to be internally protected from effluent-induced corrosion. All discharges shall be agreed by the National Administration.

Section 8
Pressure vessels

8.1 General

8.1.1 Pressure vessels are to be in accordance with the requirements of the relevant Sections of ~~*Pt 5, Ch 10 Steam Raising Plant and Associated Pressure Vessels* or~~ *Pt 5, Ch 11 Other Pressure Vessels*, as applicable, or with agreed Codes and specifications normally used for similar plants in land installations, suitably modified and/or adapted for the marine environment.

Section 13
Carbon emissions abatement plant

13.1 General

13.1.1 The requirements given in *Pt 5, Ch 24, 1 General* to *Pt 5, Ch 24, 10 Storage and use of chemicals* are applicable to Carbon emissions abatement plant unless otherwise stated.

13.1.2 The requirements in this section apply to Carbon emissions abatement plant making use of amine-based chemical solvents for carbon capture and are considered to satisfy the safety goals and corresponding functional requirements for emissions abatement systems in *Pt 5, Ch 24, 1.1 Scope* and *Pt 5, Ch 24, 2.1 Functional requirements of emissions abatement plant*. To support innovation, where the use of other carbon capture technologies or deviation from the requirements in this section is proposed, compliance with the goals and functional requirements themselves will need to be demonstrated to the satisfaction of LR.

13.1.3 The build-up of hazardous material in the system, pipes and tanks is to be prevented (e.g. Purging and inerting).

13.1.4 The carbon dioxide ‘triple point’ is to meet the requirements of *Ch 17.21 Carbon dioxide: high purity* and *Ch 17.22 Carbon dioxide: reclaimed quality* of the *Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquefied Gases in Bulk*.

13.1.5 The requirements of *Ch 17 Special Requirements* of the *Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquefied Gases in Bulk*, related to carbon dioxide are to be considered in the risk assessments and satisfied as applicable.

13.1.6 Accumulation of flammable or toxic gas concentrations and asphyxiation shall be prevented as applicable.

13.1.7 The specific Material Safety Data Sheets (MSDS) of the chemicals before and after usage (or saturated or unsaturated) and details including the mixing percentages of amine chemical composition are to be carried on board for handling of hazardous and non-hazardous chemicals used in the emissions abatement plant.

13.2 Risk assessment and Risk Based Certification (RBC)

13.2.1 Risk assessments shall be undertaken in accordance with LR's Risk Based Certification (RBC) process, where the risk assessments may identify required design changes to equipment, components, arrangements and safeguards to meet an agreed risk criteria.

13.2.2 The risk assessments are to be undertaken to ensure that risks arising from the use of Carbon emissions abatement plant to persons on board, or to the safe operation of the ship, are identified, minimized and satisfactorily managed. Risk assessments are to be documented in accordance with LR's RBC process.

13.2.3 The risk assessments are to consider normal operation, including maintenance, and reasonably foreseeable abnormal operation, e.g. caused by foreseeable failures.

13.2.4 The risks shall be assessed using acceptable and recognized risk analysis techniques, such as those detailed in ISO 31010 *Risk Management – Risk Assessment Techniques*, and loss of function, component damage, toxicity, fire and explosion shall be considered. The analysis shall help ensure that risks are eliminated wherever possible. Risks which cannot be eliminated shall be mitigated as necessary. Details of risks, and the means by which they are mitigated, shall be documented to the satisfaction of LR and in accordance with LR's RBC process.

13.3 Information to be submitted

13.3.1 In addition to the information and plans required in *Pt 5, Ch 24, 3 Information to be submitted*, the following are to be submitted for consideration:

- Material Safety Data Sheets (MSDS) and details for handling, storage and fire-fighting of hazardous and non-hazardous chemicals used in the emissions abatement plant in accordance with *Pt 5, Ch 24, 6.1 General 6.1.7*. Where mixtures are used, the mixture's specific MSDS shall be provided;
- Reports of the risk-based studies, as applicable, *see Pt 5, Ch 24, 13.2* Risk assessment and Risk Based Certification (RBC);
- Details of the maximum and minimum ambient and sea water temperatures within which the emissions abatement plant is designed to operate, and maximum and minimum ambient air temperature and humidity where relevant, i.e. where operation is temperature or humidity dependent;
- Emergency shutdown (ESD) arrangements;
- Arrangements and locations of vent mast and venting for the Carbon emissions abatement plant;
- Details of the corrosivity of wash water for scrubbing systems as applicable, e.g. specific gravity, temperature, pH, and presence of polluting substances such as oil content and turbidity;
- The Pitting Resistance Equivalent Number (PREN) is to be confirmed when stainless steels or nickel-based alloys are used for the scrubbing system containing wash water;
- For scrubber towers, a Manufacturer's Certificate for materials and welding details including procedure;
- For plant which are to be installed in hazardous areas:
  - Details, plans and arrangements required by *Pt 6, Ch 2, 14 Electrical equipment for use in explosive gas atmospheres or in the presence of combustible dusts*;
  - A schedule of equipment for use in explosive atmospheres as required by *Pt 6, Ch 2, 1.2 Documentation required for design review 1.2.9*;
- Type Approval Certification where required by the LR Rules, *see Pt 6, Ch 1, 2 Essential features for control, alarm, monitoring and safety systems*;
- For retrofit installations, in addition, the existing relevant P&IDs along with details of any modifications required, such as cross connection, tank construction, air vent, overflow lines, hull penetration, structure/tank local strength, etc.;
- For retrofit installations, a revision of the stability and loading calculations based on the additional weights of the Carbon emissions abatement plant system;
- For retrofit installations, a revision of electrical load analysis;
- Material specification, temperature and pressure ratings of piping, valves and fittings used to integrate plant and associated equipment into the emission abatement system;
- General arrangement of the ship showing layout of the emission abatement installation, including major items of electrical equipment;
- An operational description for the control system;
- Fire detection, extinction and suppression arrangements of compartment(s) where the emission abatement system and associated chemicals are stored/in use, as applicable. This is to include specific extinguishing requirements and compatibility with materials/chemicals used;
- An operating and maintenance instruction manual for the Carbon emissions abatement plant.

13.3.2 In addition to the information and plans required in *Pt 5, Ch 24, 13.3 Information to be submitted 13.3.1*, the following are to be submitted for the refrigerating plant and systems:

(a) Schematic plans, including full particulars of piping and instrumentations, for:
- primary and secondary refrigeration systems,
- gas reliquefaction systems, and
- condenser cooling water systems;

(b) Detailed dimensioned plans and material specifications;

(c) General arrangement of the refrigerating machinery compartment in elevation and plan, showing the location and arrangement of the plant, ventilation details and the location of temperature sensors and vapour detectors;

(d) Details of automatic controls, alarms and safety systems;

(e) Details of level indicators;

(f) Capacity calculations for pressure relief valves and/or bursting discs, and discharge pipe pressure drop calculations.

13.3.3 Operations manuals describing essential procedures for handling of Carbon emissions abatement plant are to be submitted. The content of the manuals shall include, but not be limited to:

(a) Properties and components of chemical, refrigerating machinery using toxic and/or flammable refrigerants, CO_2, auxiliary systems for conditioning the process that use toxic or flammable liquids or vapours;

(b) Carbon emissions abatement plant Safety system;

(c) Carbon emissions abatement plant handling system;

(d) Storage tank venting system;

(e) overall operation of the ship from dry-dock to dry-dock, including procedures for process tank cooldown and warm-up, transfer including ship-to-ship and shore transfer, sampling, gas-freeing, tank cleaning and changing process product;

(f) Process temperature and pressure control systems;

(g) Process system limitations, including minimum temperatures in process system and inner hull, maximum pressures, transfer rates, filling limits and sloshing limitations;

(h) Nitrogen and inert gas systems;

(i) Fire-fighting procedures: operation and maintenance of firefighting systems and use of extinguishing agents;

(j) Special equipment needed for the safe handling of the particular process product;

(k) Fixed and portable liquid and gas detection;

(l) C ontrol, alarm and safety systems;

(m) Emergency shutdown systems;

(n) Procedures to change process tank pressure relief valve set pressures;

(o) Emergency procedures, including process tank relief valve isolation, single tank gas-freeing and entry and emergency ship-to-ship and shore transfer operations.

13.4 Containment (storage tank) system and use of chemicals

13.4.1 Containment systems are to meet the requirements of *Ch 4 Cargo Containment* of the *Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquid Chemicals in Bulk*, and/or *Ch 4 Cargo Containment* of the *Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquefied Gases in Bulk,* as applicable.

13.4.2 The holding tanks for residues generated from the Carbon emissions abatement plant process are to satisfy the following requirements in consideration with MSDS, as applicable:

(a) The tanks are to be independent from other tanks, except in cases where these tanks are also used as the overflow tanks for chemical treatment fluids storage tanks.

(b) Tank capacities are to be decided in consideration of the number and kinds of installed Carbon emissions abatement plant systems as well as the maximum number of days between ports where residue can be discharged ashore. In the absence of precise data, a figure of 30 days is to be used.

(c) Where residue tanks used in closed loop chemical treatment systems are also used as the overflow tanks for chemical treatment fluid storage tanks, the requirements for storage tanks apply.

13.4.3 Chemical storage ~~tanks~~ in bulk and in package fall under *IBC* and IMDG Codes as bulk product or as package product respectively, as applicable in consideration with MSDS and risk-based studies.

13.4.4 CO_2 tank pressure/temperature control

(a) With the exception of tanks designed to withstand full gauge vapour pressure of the CO_2 under conditions of the upper ambient design temperatures, tank pressure and temperature shall be maintained at all times within their design range by one, or a combination of, the following methods:
- reliquefaction of vapours;
- pressure accumulation; and
- liquid cooling.

(b) Venting of the CO_2 to maintain tank pressure and temperature shall not be acceptable except in emergency situations. The administration may permit this to be controlled by venting vapours to the atmosphere at sea. This may also be permitted in port with the authorisation of the port administration. This is subject to separate consideration and application.

(c) CO_2 tank pressure/temperature control are to meet the requirements of *Ch 7 Cargo Pressure/Temperature Control* of the *Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquefied Gases in Bulk*, as applicable in consideration with risk-based studies.

13.4.5 Vent systems for CO_2 containment are to meet the requirements of *Ch 8 Vent Systems for Cargo Containment* of the *Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquefied Gases in Bulk*, as applicable in consideration with risk-based studies.

13.4.6 The corrosion-resistant coating used inside the storage tank is to be confirmed as being suitable for the expected operating temperatures and pressures, and corrosive properties of the chemicals. The tank vent piping connected to the storage tank is to be similarly coated. *See Pt 5, Ch 24, 4.1 General 4.1.2* and *Pt 5, Ch 24, 5.1 General 5.1.10*.

13.4.7 The storage tank is to be arranged so that the tank can be emptied and ventilated by means of portable or permanent systems.

13.4.8 The containment system and storage tanks shall be located outside of accommodation spaces and machinery spaces of category A. They shall be considered as part of any damage stability calculations required by applicable damage stability criteria. The location of the containment system and tanks shall be in keeping with all applicable pollution regulations.

13.4.9 The tank is to be fitted with pressure or vacuum relief valves to limit the pressure or vacuum in the tank.

13.4.10 All types of containment systems (storage tanks), including novel concepts and configuration for CO_2 storage, are to comply with the requirements of *Ch 4 Cargo Containment* of the *Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquefied Gases in Bulk*, as applicable.

13.4.11 Pressure vessels are to be in accordance with the requirements of the following:

- *Pt 5, Ch 24, 8 Pressure vessels*; and/or
- *Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquid Chemicals in Bulk*; and/or
- *Ch 4 Cargo Containment* of the *Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquefied Gases in Bulk*; and/or
- *Part A1, 6.5.1* the design of the tank and *6.4.15.3 Type C independent tanks* of the *Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint Fuels*, as applicable.

13.4.12 The stowage of portable storage tanks is to comply with the requirements of the International Maritime Dangerous Goods (IMDG) Code and/or *Chapter 17 - Discharging and Loading of Portable Tanks on Board of the International Codes - OSV Chemical Code - Code for the Transport and Handling of Hazardous and Noxious Liquid Substances in Bulk on Offshore Support Vessels*, as applicable in consideration with risk-based studies, *see Pt 5, Ch 24, 13.2 Risk-based studies*.

13.4.13 The ISO container tank structure is to be in accordance with the requirements of the *International Convention for Safe Containers,* MSC/Circ.860, EN 12079 *Offshore containers and associated lifting sets*, and/or ISO 10855 *Offshore containers and associated lifting sets*.

13.4.14 Portable tanks used for CO_2 storage shall have safety measures equivalent to those of permanent CO_2 tanks.

13.4.15 The hull structure of CO_2 and amine solvent containment (storage tanks) is to comply with the relevant requirements of:

- *Pt 3 Ship Structures (General)* and *Pt 4 Ship Structures (Ship Types)*; and/or
- *Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquid Chemicals in Bulk*; and/or
- *Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquefied Gases in Bulk* as applicable, except where stated otherwise in this Chapter.

13.4.16 Amine solvent (ethanolamine solution)

(a) These ethanolamine solutions are commonly used as a chemical treatment fluid for Carbon emissions abatement plant systems, and are hereinafter referred to as chemical treatment fluid. Chemical storage tanks that contain chemical treatment fluid, degraded chemical treatment fluid and waste chemical treatment fluid are to comply with the requirements given in *Pt 5, Ch 24, 10.1 General 10.1.2* to *Pt 5, Ch 24, 10.1 General 10.1.19* and *Pt 5, Ch 24, 5.1 General 5.1.7* of these Rules, and/or *2 Ship Survival Capability and Location of Cargo Tanks, 4 Cargo Containment* and *17 Summary of Minimum Requirements* of the *Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquid Chemicals in Bulk*, and/or provisional categorization of liquid substances in accordance with MARPOL ANNEX II and the IBC code (MEPC.2/Circ.28 (Latest circular)), as applicable and in consideration with the MSDS. For emissions abatement plant using chemicals other than the above, safety measures are to be taken according to the MSDS and risk-based studies.

(b) Chemical storage tanks containing chemical treatment fluids are to have sufficient strength to withstand a pressure corresponding to the maximum height of a fluid column in the overflow pipe, with a minimum of 2,4 m above the top plate, taking into consideration the density of the chemical treatment fluid, saturated with CO_2, as applicable.

13.5 Ship arrangements

13.5.1 The CO_2, chemical treatment fluid, other substance and effluent tanks are to be protected from mechanical damage. This may be achieved either by installation in spaces where there are no cargo or vehicle movements and where no heavy lifting operations are expected, or by mechanical protection, if installed in spaces where such operations may take place. Alternative proposals demonstrating equivalent or increased protection against damage may be considered.

13.5.2 The arrangement of CO_2 tanks, storage and system is to meet the requirements of *Ch 3 Ship Arrangements* of the *Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquefied Gases in Bulk*, as applicable in consideration with risk-based studies.

13.5.3 Where chemical treatment fluid is stored in integral tanks, these are to comply with *Pt 5, Ch 24, 10.1 General 10.1.5, Pt 5, Ch 24, 13.4 Containment (storage tank) system and use of chemicals 13.4.16 (a)*, and are to be segregated by cofferdams, void spaces, pump-rooms, empty tanks or other similar spaces so as to not be located adjacent to accommodation, cargo spaces containing cargoes which react with chemical treatment fluids in a hazardous manner, and any food stores, oil tanks or fresh water tanks. Where a cofferdam is impracticable, alternative arrangements in consideration with risk-based studies, the goals and functional requirements themselves will need to be demonstrated to the satisfaction of LR. In addition, *Pt 3, Ch 3, 4.7 Separation and protection of tanks 4.7.1 to 4.7.4* can be referenced.

13.5.4 The structural requirements are to comply with the relevant LR Rules and Statutory Requirements as applicable and separately approved. Consideration is to be given to Carbon emissions abatement plant space boundaries, fire integrity, hull penetrations, compressed and liquefied gases, and chemical storage tank constructions, if fitted. *See Pt 5, Ch 24, 5 Materials*.

13.5.5 Bunkering station (loading/off-loading) locations, arrangements, piping and vents are to comply with the following:

- *Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquid Chemicals in Bulk*; and/or the requirements of the
- *Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquefied Gases in Bulk*; and/or
- *Part A-1* and/or *Appendix LR1, Part A-1 – Requirements for Ships Using Methyl Alcohol (Methanol) or Ethyl Alcohol* of the *Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint Fuels*, as applicable.

13.5.6 Tank connection spaces shall be in accordance with

- *Part A1* and/or *Appendix LR1, Part A/Part A-1 – Requirements for Ships Using Methyl Alcohol (Methanol) or Ethyl Alcohol* of the *Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint Fuels*, and/or
- *Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquefied Gases in Bulk*, as applicable.

13.5.7 Refrigerating machinery and refrigerant storage compartments

(a) General

- Refrigerating machinery is to be located in a well-ventilated compartment. In general, the arrangements are to be such that all components of the refrigerating machinery can be readily opened up for safe maintenance, inspection or replacement.
- Refrigerating machinery using toxic and/or flammable refrigerants is to be located outside the main machinery space in a separate gastight compartment.
- Where the refrigerating machinery is located in a separate gastight compartment, outside the main machinery space, this compartment is to be equipped with effective mechanical ventilation to provide 30 air changes per hour based upon the total volume of the space. The mechanical ventilation is to have two main controls, one of which is to be operable from a place outside the compartment.
- Refrigerating machinery using non-toxic and non-flammable refrigerants will not, in general, be required to be located in a separate compartment outside the main machinery space, as applicable in consideration with risk-based studies.
- Openings for pipes, electrical cables and other fittings in the bulkheads and deck are to be fitted with gastight seals.
- Ammonia piping shall not be led directly through accommodation spaces, service spaces, electrical equipment rooms or control stations.

(b) Arrangements for compartments housing machinery using ammonia

- Where ammonia refrigerant is used, the refrigerating machinery shall be installed in a dedicated gastight compartment.
- The compartment containing ammonia refrigerating machinery and any accessways are to be provided with independent mechanical ventilation capable of:
  - removing the heat generated by the equipment installed in the compartment;
  - maintaining the atmosphere in the compartment at acceptable vapour threshold levels under normal operating conditions; and
  - disposing of ammonia vapour safely and quickly in the event of a major leakage.
- The ventilation system is to be of the negative pressure type where abnormal stoppages of the extraction fans activate an audible and visual alarm.
- Compartments containing ammonia refrigerating machinery, including process vessels, are to be provided with:
  - a negative ventilation system, independent of ventilation systems serving other spaces, having a capacity of not less than 30 air changes per hour based upon the total volume of the space. Other suitable arrangements which ensure an equivalent effectiveness may be considered;
  - fresh air inlets, located at a low level in the machinery compartment and arranged so as to provide a supply of fresh air and to minimise the possibility of re-cycling the exhaust air from the outlet;
  - exhaust outlets, located at a high level and arranged so as to promote good air distribution throughout the compartment;

- a fixed ammonia detector system with alarms inside and outside the compartment. For the ammonia concentration limit (ppm), *see Table 1 Control, alarm and safety systems* of *Appendix LR2 – Requirements for Ships Using Ammonia as Fuel* of the *Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint Fuels*.
- water screens above all access doors, operable manually from outside the compartment in all ambient conditions;
- an independent bilge system;
- where the charge is greater than 50 kg, emergency body shower and eye wash facilities installed locally outside the compartment. The water for the shower is to be thermostatically controlled so as to avoid low temperature shock.

- Compartments are to have at least two access doors, opening outwards, one of which is to be an emergency exit giving direct access to the open deck. The doors are to be fitted with an easily operated opening mechanism to facilitate rapid escape in an emergency. In the case of small compartments where more than one door would be impractical, the emergency exit only is to be provided.
- At least two sets of self-contained breathing apparatus and protective clothing are to be provided, readily available in the vicinity of the compartment but external to the area of risk.
- The location of the exhaust duct, from the compartment or area, is to be free from obstruction and be such as not to cause danger. A horizontal distance of 15 m and a vertical distance of 6 m from other ventilation intakes and openings to accommodation and other enclosed areas need to be applied, *see Appendix LR2, LR Part A-1, 12.6 Toxic area zones – Requirements for Ships Using Ammonia as Fuel* of the *Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint Fuels*.
- Ventilation fans are not to produce a source of vapour ignition in either the ventilated compartment/area or the ventilation system. Ventilation fans and fan ducts, in way of fans only, are to be of non-sparking construction.
- In the case of ammonia plants with a charge of ammonia not greater than 25 kg, the refrigerating machinery may be located in the main machinery space provided it complies with the following requirements:
  - the entrance to the machinery space is properly illuminated and marked and has warning signs permanently posted;
  - the area where the ammonia machinery is installed is served by a hood with a negative ventilation system, so as not to permit any leakage of ammonia dissipating into other areas;
  - a waterspray system is provided for the area;
  - coamings, of not less than 150 mm in height, are installed around the ammonia machinery area;
  - a fixed ammonia detector system with alarms inside and outside the main machinery space is provided;
  - means are provided for stopping the ammonia compressor prime movers from a position outside the machinery space;
  - at least two sets of self-contained breathing apparatus and protective clothing are to be provided, readily available in the vicinity of the compartment but external to the area of risk;
  - air intakes of other machinery are located away from the ammonia machinery area as far as is practicable.

(c) Gas storage compartments

- Portable steel cylinders containing reserve supplies of refrigerant are to be stored in a well-ventilated compartment reserved solely for this purpose.
- The compartment is to be provided with a mechanical ventilation system providing ten air changes per hour and is to have at least one door opening outwards giving direct access to open deck.
- Bulk storage tanks holding more than 150 kg of replacement carbon dioxide are to be located in a separate compartment. The compartment is to be provided with a mechanical ventilation system having a minimum capacity of six air changes per hour. The ventilation system exhaust ducting is to remove air from the base of the compartment. The compartment is to be fitted with a gastight access door opening outward.
- The compartment is to be provided with a refrigerant vapour detection system.
- The compartment is to be provided with suitable water drainage arrangements not connected with the main machinery spaces.
- Steel storage cylinders are to be of an approved type, supplied by the refrigerant manufacturer and filled to a level suitable for an ambient temperature of +46°C.
- The compartment is to be provided with racks to facilitate secure stowage of the cylinders.

(d) Compartments housing carbon dioxide containing equipment

- Self-closing gastight access doors are to be provided between each compartment and the dedicated escape routes.
- In compartments which are normally occupied and where the volume of ventilation required by *Pt 5, Ch 24, 13.5 Ship arrangements 13.5.7 (a)* is not desirable, a negative pressure ventilation system, capable of ten air changes per hour, is required to be fitted. This ventilation system is to be automatically activated when, in the event of a leak, the concentration of carbon dioxide reaches a predetermined level but in no case higher than the threshold limit value of 5000 ppm.

13.6 Piping systems

13.6.1 Piping systems which carry chemical substances are to meet the requirements of *Ch 5 Cargo Transfer* and *Ch 6 Materials of Construction and Welding* of the *Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquid Chemicals in Bulk* and the *Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquefied Gases in Bulk*. Use of non-metallic materials will be specifically considered.

13.6.2 Piping systems for compressed liquefied gas and CO_2 are to meet the requirements of the *Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquefied Gases in Bulk*, as applicable.

13.6.3 Piping systems utilising plastic pipes are to meet the requirements of *Pt 5, Ch 12 Piping Design Requirements*.

13.6.4 Modifications to tank, air and overflow systems, air pipe closing appliances, and other systems and equipment are subject to special approval.

13.6.5 Connections to piping systems for taking CO_2 liquid samples shall be clearly marked and shall be designed to minimise the release of vapours. The sampling system shall be of a closed loop design to ensure that CO_2 liquid and vapour are not vented to atmosphere.

13.6.6 For any product heating or cooling medium, provisions shall be made to detect the leakage of toxic or flammable vapours into an otherwise non-hazardous area or overboard in consideration with risk-based studies, *see Pt 5, Ch 24, 13.2 Risk-based studies*. Any vent outlet from this leak detection arrangement shall be to a safe location and be fitted with a flame screen.

13.6.7 The ventilation system for the CO_2 handling system is to meet the requirements of *Ch 12 Artificial Ventilation in the Cargo Area* of the *Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquefied Gases in Bulk*, as applicable in consideration with risk-based studies, *see Pt 5, Ch 24, 13.2 Risk-based studies*.

13.6.8 Piping intended for chemicals is to be joined by welding and composed of Class II piping systems. *See IBC Code, Sections 5.2 and LR6.3(b)*.

13.6.9 The valves connecting the piping systems to the storage tank and fitted below the tank top are to be equipped with quick closing facilities operable from a safe position outside the space.

13.6.10 The pressure relief system of the compressed and liquefied CO_2 portable storage tanks shall be connected to a fixed venting system.

13.6.11 After connection of the compressed and liquefied CO_2 portable storage tanks to the ship's CO_2 piping system:

(a) each portable tank shall be capable of being isolated at any time, with the exception of the pressure relief system;

(b) isolation of one tank shall not impair the availability of the remaining portable tanks.

13.6.12 Piping intended for CO_2 is to be joined by welding and composed of a Class II piping system, and a vapour line greater than 4 MPa or a liquid line greater than 1,6 MPa are to be composed of a Class I piping system.

13.6.13 The portable tanks' connections to the ship's piping systems shall be made by means of approved flexible hoses or other suitable means designed to provide sufficient flexibility.

13.6.14 Arrangements for portable tanks shall be provided to limit the quantity of liquid and gas spilled in case of inadvertent disconnection or rupture of the non-permanent connections.

13.6.15 Amine solvent (ethanolamine solution) piping

(a) Pipes/piping systems containing ethanolamine solution are to be of steel or other equivalent material with a melting point above 925°C, except downstream of a tank valve, provided that this valve is metal seated and, in the event of fire, is either arranged as fail-to-closed or equipped with quick closing facilities operable from a safe position outside the space. In such cases, Type Approval of plastic pipes may be waived off under the provision of *Pt 5, Ch 12, 5 Plastic pipes*.

(b) Drip trays shall be fitted where leakage may occur and made of suitable material. Each tray shall have a sufficient capacity to ensure that the maximum amount of spill according to the risk assessment can be handled.

(c) Pipework and transfer systems which may carry ethanolamine solution are to meet the requirements of:

- *Pt 5, Ch 12 Piping Design Requirements*;
- *Pt 5, Ch 13 Ship Piping Systems*;
- *Pt 5, Ch 14 Machinery Piping Systems*; and
- *Ch 17 Summary of Minimum Requirements* of the *Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquid Chemicals in Bulk*, as applicable.

Where it is proposed to apply corrosion-resistant lining to steel pipe systems then such lining is to be confirmed as being suitable for the application, in accordance with *Pt 5, Ch 24, 4.1 General 4.1.2*. The elasticity of the lining is not to be less than that of the supporting boundary material.

(d) Materials used for amine solvent storage tanks and associated piping systems are to be resistant to such chemicals and constructed in accordance with the *Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquid Chemicals in Bulk*, as applicable. In addition, API RP 945 *Avoiding Environmental Cracking in Amine Units* can be referenced for amine application.

(e) The amine solvent shall be contained in a closed-loop system that is independent from other piping systems.

13.7 Refrigeration plant, pipes, valves and fittings

13.7.1 General requirements for refrigerating compressors

(a) A check valve is to be fitted to each compressor discharge.

(b) Where off-loading devices are incorporated, arrangements are to be provided which indicate the extent of the offloading being affected.

(c) A pressure relief valve and/or safety disc is to be fitted between each compressor and its gas delivery stop valve in accordance with *Pt 5, Ch 24, 13.7 Refrigeration plant, pipes, valves and fittings 13.7.13 (e)* and *Pt 5, Ch 24, 13.7 Refrigeration plant, pipes, valves and fittngs 13.7.13 (f)*.

(d) Stop valves are to be provided on compressor suctions and discharges.

(e) Suction strainers and lubricating oil filters are to be provided and so arranged that they are easily accessible for cleaning or renewal of the filter elements.

(f) The correct direction of rotation is to be permanently indicated.

(g) Where any hermetic or semi-hermetic compressor has its electric motor cooled by the circulating refrigerant, the following arrangements are to be provided:

- Refrigeration circuits are to contain no more than one hermetic or semi-hermetic compressor.
- Every compressor motor is to be fitted with a thermal cut-out device to protect the motor against overheating.
- In each refrigeration circuit containing a hermetic or semi-hermetic compressor, suitable arrangements shall be provided to remove debris and contaminants resulting from a motor failure. *See Pt 5, Ch 24, 13.7 Refrigeration plant, pipes, valves and fittings 13.7.14 (a)*.
- The pressure envelope of any hermetic or semi-hermetic compressor exposed to the refrigerant pressure is to be designed and constructed in accordance with the requirements of *Pt 5, Ch 11 Other Pressure Vessels* and *Pt 5, Ch 17 Requirements for Fusion Welding of Pressure Vessels and Piping*, as applicable. Plans are to be submitted for consideration as required by *Pt 5, Ch 11, 1.6 Plans*.

13.7.2 Reciprocating compressors

(a) An oil level sight glass is to be fitted to the crankcase.

(b) Compressors with cylinder bores in excess of 50 mm in diameter are to be provided with arrangements to relieve high cylinder pressures such as would result from 'hydraulic lock' (i.e. liquid refrigerant in the cylinders). Alternatively, the provision of positive means to prevent liquid refrigerant reaching the compressor may be accepted.

13.7.3 Screw compressors

(a) The rotor casing is to be designed for the maximum pressure to which it may be subjected.

13.7.4 Pressure vessels and heat exchangers

(a) The term 'pressure vessel' will normally apply to receivers and heat exchangers, and does not include any of the following:

- compressors;
- liquid refrigerant pumps;
- pipes and their fittings.

The use of plate heat exchangers is to be in accordance with the requirements of *Pt 5, Ch 11, 11 Plate heat exchangers*.

(b) Where ammonia is the refrigerant, the pressure vessels are to be constructed to at least Class 2/1 requirements.

(c) Pressure vessels for the containment of primary refrigerants for use in conventional refrigeration circuits where the pressure/saturation temperature relationship applies are not required to be low temperature impact tested unless the design temperature is lower than −40°C.

(d) Pressure vessels are to be thermally insulated to an extent that will minimise condensation of moisture from the surrounding atmosphere. The insulation is to be provided with an efficient vapour barrier and adequately protected from mechanical damage. Prior to applying the insulation, the steel surfaces are to be suitably protected against corrosion.

(e) Each pressure vessel which may contain liquid refrigerant and which is capable of being isolated is to be protected with overpressure relief devices, *see Pt 5, Ch 24, 13.7 Refrigeration plant, pipes, valves and fittings 13.7.13.*

13.7.5 Condensers, oil coolers and evaporators

(a) In order to minimise the risk of corrosion, where the refrigerant is ammonia, the material interface between the primary refrigerant and cooling water or secondary refrigerant is to be of a suitable grade of stainless steel. Carbon-manganese steel with a suitable inhibitor would also be acceptable.

(b) Space is to be provided for safe maintenance, inspection or replacement of condenser and evaporator tubes, *see Pt 5, Ch 24, 13.5 Ship arrangements 13.5.7 (a)*.

(c) Where ammonia is used as the refrigerant, the refrigerating plant is to comply with the following additional requirements:

- Automatic air purgers are to be provided, with their discharges being led through water before venting to atmosphere.
- The cooling water returns from sea-water cooled condensers are not to be led into the main machinery spaces.
- Fresh water condenser cooling systems are to be provided with pH meters to activate audible and visual alarms in the event of an ammonia leak.

13.7.6 Liquid receivers

(a) Primary refrigerating systems are to be provided with liquid receivers with sufficient capacity to hold the complete refrigerant charge, in order to prevent emission of the refrigerant to the atmosphere during servicing or repairs.

(b) Alternatively, in systems using a secondary refrigerant, with a number of units, smaller receivers may be used provided the system includes a common storage receiver with sufficient capacity to hold at least the primary refrigerant charge from two units. The common receiver is to be provided with the necessary crossover connections to facilitate transfer of refrigerant to and from each unit in the system.

13.7.7 Oil separators

(a) Oil separators are to be provided at compressor discharges and are to be fitted with a control arrangement to enable the separated oil to be returned to the compressor crankcase. Wire gauze used in separators is to be sufficiently robust and well supported.

13.7.8 Refrigerant pumps

(a) Primary and, where appropriate, secondary refrigerant pumps are to be provided with pressure relief valves, *see Pt 5,Ch 24, 13.7 Refrigeration plant, pipes, valves and fittings 13.7.13 (c)*.

13.7.9 Condenser cooling water pumps

(a) Suitable spring-loaded safety valves are to be provided in each cooling water circuit, *see Pt 5, Ch 24, 13.7 Refrigeration plant, pipes, valves and fittings 13.7.13 (c)*.

13.7.10 Piping systems

(a) All piping, valves and fittings are to be suitable for the maximum pressure to which the system can be subjected and are to comply with the requirements of *Pt 5, Ch 12 Piping Design Requirements*.

(b) Pipework for ammonia (R–717) is to comply with Class 1 requirements.

(c) In addition to visual examination of pipe welds, Non-Destructive Examination of pipe welds is to be carried out in accordance with the requirements of *Ch 13 Requirements for Welded Construction* of the *Rules for the Manufacture, Testing and Certification of Materials*, to the satisfaction of the Surveyors.

(d) All steel pipework on the low temperature part of the system is to be protected against external corrosion. Protective coatings are to be removed from pipe surfaces to a distance of not less than 50 mm either side of the joint weld preparations prior to welding. On completion of welding and testing, a protective coating is to be applied.

(e) Where brine is the secondary refrigerant, piping and tanks shall not be galvanised on the brine side. If any parts of the brine system have been galvanised, the brine cooling and return tanks are to be provided with a ventilating pipe or pipes led to the atmosphere in a location where no damage will arise from the gas discharged. The ventilation pipes are to be fitted with wire gauze diaphragms which can be readily renewed.

(f) Copper piping is to be manufactured in accordance with *Pt 5, Ch 12, 3 Copper and copper alloys*, except in the case of small air coolers having finned pipes of outside diameter not greater than 19 mm and which have been fabricated under workshop conditions. The finned pipes may have a minimum wall thickness of 0,5 mm when used with R–22 and R–134a refrigerants.

(g) Where the use of plastic piping is proposed in a secondary refrigerant system (e.g. brine), it is to be in accordance with *Pt 5, Ch 12, 5 Plastic pipes*.

(h) Pipelines are to have ample provision for expansion and contraction in service conditions. In general, expansion bends are to be used for this purpose. However, the use of metallic expansion bellows will be accepted, provided test data is produced showing satisfactory strength and fatigue properties under the appropriate conditions.

(i) All pipelines are to be fully supported and secured so as to prevent vibration. Flexible hoses may be used, where necessary, to prevent transmission of vibration so long as the documentation outlined in *Pt 5, Ch 24, 13.7 Refrigeration plant, pipes, valves and fittings 13.7.10 (h)* is provided. Flexible hoses are to be of a type which has been approved by LR, *see Pt 5, Ch 12, 7 Flexible hoses.*

(j) Pipework which may contain low temperature refrigerant, except within secondary refrigerant cooler rooms, is to be thermally insulated to an extent that will minimise condensation of moisture. Insulation in preformed sections is recommended. If *in situ* foamed insulation is employed, pre-production testing on site is to be carried out to the satisfaction of the Surveyor, using a 'mock-up' representative of the system to be employed.

(k) All pipe insulation is to be provided with an efficient vapour barrier, care being taken to ensure that it is not interrupted in way of supports, valves, etc. In addition, adequate protection of insulation surfaces from mechanical damage is to be provided.

(l) Where refrigerating piping is embedded in the cargo chamber insulation, the locations of the pipe joints are to be marked on the outside of the insulation lining.

13.7.11 Joints

(a) Butt welded pipe joints are to be employed as far as practicable. Socket welded pipe joints are acceptable up to 25 mm diameter. Flanged or other joints are to be kept to a minimum and, in general, are to be restricted to connections with items of machinery or components which may have to be removed for maintenance purposes. Connections to valves are normally to be welded unless they are of a type, or in a position, which precludes *in situ* maintenance.

(b) Pipe connections to fittings (e.g. gauge lines, level controls) which are likely to be subjected to heavy corrosion are to be of heavy gauge construction or made from suitable corrosion-resistant materials.

13.7.12 Liquid level indicators

(a) Where liquid level indicators of the 'see-through' variety are used, they are to be of the flat plate type incorporating glass (or equivalent material) of heat-resistant grade.

(b) All level indicators are to be provided with automatic shut-off devices and isolating valves. Plate-type sight glasses which form an integral part of the component in which they are mounted (e.g. compressor crankcases, pressure vessels) are exempt from this requirement.

(c) All level indicators are to be suitable for the system maximum working pressure and tested accordingly.

13.7.13 Overpressure protection devices

(a) Refrigeration systems are to be provided with relief devices, but it is important to avoid circumstances which would bring about an inadvertent discharge of refrigerant to the atmosphere. The system is to be so designed that pressure due to fire conditions will be safely relieved.

(b) Pressure relief devices are to be mounted in such a way that it is not possible to isolate them from the part of the system which they are protecting except that, where duplicated, a changeover valve may be fitted which will allow either device to be isolated for maintenance purposes without it being possible to shut off the other device at the same time.

(c) Relief discharge is to be led to a safe place above deck away from personnel accesses and air intakes. Discharge piping shall be designed to preclude ingress of water, dirt or debris which may cause the equipment to malfunction.

(d) For ammonia systems, discharge from relief valves is to be led through water before venting to the atmosphere. Vapour detectors are to be provided in the discharge pipes to activate audible and visual alarms in the event of a leakage of ammonia.

(e) A pressure relief valve and/or bursting disc is to be fitted between each positive displacement compressor and its gas delivery stop valve, the discharge being led to the suction side of the compressor. The flow capacity of the valve or disc is to exceed the full load compressor capacity on the particular refrigerant at the maximum potential suction pressure. For these internal relief valves, servo-operated valves will be accepted. Where the motive power for the compressor does not exceed 10 kW, the pressure relief valve and/or bursting disc may be omitted.

(f) Compressors protected by bursting discs are to be provided with automatic shutdown in the event of high discharge temperatures.

(g) Each compressor is to be provided with automatic shutdown in the event of high discharge pressure. For refrigeration systems where the maximum working pressure is less than or equal to 4 MPa, the automatic shutdown is to operate at a pressure in excess of normal operating pressure but no greater than 0,9 of the maximum working pressure. For refrigeration systems where the maximum working pressure is greater than 4 MPa, the automatic shutdown is to operate at a pressure in excess of normal operating pressure but no greater than 0,95 of the maximum working pressure.

(h) Sections of systems and components which could become full of liquid between closed valves are to be provided with pressure relief devices relieving to a suitable point in the refrigerant circuit.

(i) Refrigerant pumps are to be provided with pressure relief valves on the discharge side, which may relieve to the suction side or to another suitable location.

(j) Suitable spring-loaded safety valves are to be provided on the cooling liquid side of condensers and the brine side of evaporators where the pressure from any pump or expansion of the liquid in the circuit could exceed the design pressure of the system or any component forming part of the cooling system.

(k) Relief valves are to be adjusted and bursting discs so selected that they relieve at a pressure not greater than the design pressure of the system, as defined in *Pt 6, Ch 3, 2.5 Design pressures*.

(l) When satisfactorily adjusted, relief valves are to be protected against tampering or interference by a wire with a lead seal or similar arrangement.

(m) Valves which are arranged to discharge to the low pressure side of the system are to be substantially independent of back pressure and are to be of a type which has been approved by LR.

(n) The rated discharge capacity of the pressure relief devices is to be determined in accordance with an appropriate recognised National Standard such as ISO 5149 *Mechanical Refrigeration Systems used for Cooling and Heating – Safety Requirements*. The discharge piping shall be sized such that the back pressure at full relief rate does not exceed 10 per cent of the relief valve set pressure.

(o) As carbon dioxide can form a solid powder at atmospheric pressure, there is a possibility that relief devices will choke if vented directly to atmosphere. The method used to guard against the formation of powder is to be submitted for consideration.

(p) In carbon dioxide systems, overpressure protection is to be fitted to pipelines or components which can be isolated in a liquid full condition. Pressure relief devices are to be arranged so as to vent vapour at all times.

(q) In cascade systems where carbon dioxide is used in combination with ammonia, the effects of carbon dioxide leaking into the ammonia side are to be considered. It may be desirable to design the ammonia system to either withstand the design pressure on the carbon dioxide side or have relief arrangements to safely deal with the additional vapour produced if a leak occurs.

13.7.14 Filters, driers and moisture indicators

(a) Suitable filters are to be provided in the refrigerant gas lines to compressors and in the liquid lines to refrigerant flow controls. Wire gauze used in filters is to be sufficiently robust and well supported. A filter may be combined with the oil separator required by *Pt 5, Ch 24, 13.7 Refrigeration plant, pipes, valves and fittings 13.7.7 (a)*. Stop valves are to be provided to allow for servicing of filters. After first commissioning of the system, the filters shall be examined to confirm that elements remain intact and not collapsed.

(b) Refrigerant filters, driers and moisture indicators are to be fitted in halocarbon refrigerant systems, and the arrangement is to be such that filters and driers can be by-passed, isolated and opened up without interrupting plant operations.

13.7.15 Purging devices. Where the operating pressure of the low pressure system may be below atmospheric, a purging device is to be provided, the discharge from which is to be led to a safe place above deck.

13.7.16 All materials used in refrigerating equipment and systems are to be suitable for use with the selected refrigerants. This includes joints, sealing materials and lubricants. For example, the following materials and refrigerants are not to be combined:

- Copper with ammonia;
- Magnesium with fluorinated hydrocarbons;
- Zinc with ammonia or fluorinated hydrocarbons.

13.7.17 For ammonia systems, the condensers/evaporators are to be manufactured from titanium or a suitable grade of stainless steel.

13.7.18 Materials used in the construction of the refrigerating equipment and associated systems are to be manufactured and tested in accordance with the requirements of the *Rules for the Manufacture, Testing and Certification of Materials*.

13.8 Refrigerated carbon dioxide installations

13.8.1 Refrigerated carbon dioxide installations are to satisfy the requirements of this Section in consideration with risk-based studies, *see Pt 5, Ch 24, 13.2 Risk assessment and Risk Based Certification (RBC)*.

13.8.2 Where reliquefaction or refrigeration equipment is fitted for temperature and pressure control, the equipment is to comply with the requirements of this Section in consideration with risk-based studies, *see Pt 5, Ch 24, 13.2 Risk assessment and Risk Based Certification (RBC)*.

13.8.3 Refrigerants and classes of pipes

(a) These Rules are applicable to the primary refrigerants in *Pt 6, Ch 3, 2.1 General, Table 3.2.1 Primary refrigerants and their class of pipe*.

(b) Attention is to be given to any Statutory Requirements regarding the use of refrigerants of the National Authority of the country in which the ship is to be registered.

(c) Within the parameters of pressures, temperatures, toxic nature and flammability, the class of pipe to be used with various refrigerants is shown in *Pt 6, Ch 3, 2.1 General, Table 3.2.1 Primary refrigerants and their class of pipe*.

(d) Design conditions as applicable to the classes of pipes are defined in *Pt 5, Ch 12, 1.5 Design temperature*.

(e) The materials of Class I and Class II piping systems are to be manufactured at a works approved by LR and tested in accordance with the appropriate requirements of the *Rules for the Manufacture, Testing and Certification of Materials*. Particular attention is drawn to *Ch 6, 4 Ferritic steel pressure pipes for low temperature service* of the *Rules for the Manufacture, Testing and Certification of Materials*, where testing requirements for pipes used for low temperature service are given.

(f) The materials of Class III piping systems are to be manufactured and tested in accordance with the requirements of acceptable national specifications. The manufacturer's test certificate will be acceptable and is to be provided for each consignment of materials.

(g) Particulars of refrigerating systems using refrigerants other than those listed will be given special consideration.

13.8.4 Refrigerants and design pressures

(a) The design pressure of the system will be regarded as equal to its maximum allowable working pressure.

(b) The maximum working pressure is the maximum permissible pressure within the system (or part system) in operation or at rest. No relief valve is to be set to a pressure higher than the maximum allowable working pressure.

(c) The design pressure of the low pressure side of the system is to be the saturated vapour pressure of the refrigerant at +46°C. Due regard is to be taken of defrosting arrangements, which may cause a higher pressure to be imposed on the low pressure system.

(d) The minimum design pressure of the high pressure side of the system (P dh) is to be 1,11P b, where P b is an allowance for the compressor high pressure cut-out. P b is to be at least equal to 1,11P a, where P a is the condenser working pressure when operating in tropical zones and equates to the saturation pressure at 46°C.

(e) Design pressures (MPa g) applicable to refrigerants are to be not less than the values given in *Pt 6, Ch 3, 2.5 Design pressures, Table 3.2.2 Pressure limits* when condensers are sea-water cooled. The design pressure for other refrigerants and condensing arrangements is to be agreed with LR.

(f) Due to the low critical temperature of carbon dioxide, it is inappropriate to determine the design pressure in accordance with *Pt 5, Ch 24, 13.8.4 (c) Refrigerants and design pressures 13.7.10 (h)*. The proposed design pressure for a carbon dioxide system is to be stated, taking account of the maximum allowable working pressure and the maximum pressure at rest conditions. Where the maximum pressure at rest condition is maintained by the fitting of a supplementary refrigeration unit, condensing the vapour in a holding vessel, a supporting calculation is to be provided to show that this can be undertaken with a local ambient temperature of 45°C. The holding vessel is to be thermally insulated to prevent the operation of the relief devices within a 24 hour period after stopping the supplementary refrigeration unit at an ambient temperature of 45°C and an initial pressure equal to the starting pressure of the refrigeration unit.

(g) Where a carbon dioxide system is designed for hot gas defrosting, due regard is to be given to the possibility of a higher pressure being imposed on the low pressure system. The design pressure for this section of the system shall be 10 per cent above the maximum pressure experienced during defrosting.

13.9 Electrical, control and safety systems

13.9.1 Where the refrigerating machinery is to be electrically driven, the requirements of *Pt 6, Ch 2, 2 Main source of electrical power* are to be complied with, as applicable.

13.9.2 Electrical equipment is not to be installed in spaces in which ammonia refrigerant is used or stored unless it is essential for operational purposes. Where electrical equipment is installed in such spaces, the requirements of *Pt 5, Ch 24, 13.9 Electrical, control and safety systems 13.9.5* and *Pt 6, Ch 2, 14 Electrical equipment for use in explosive gas atmospheres or in the presence of combustible dusts* are to be complied with.

13.9.3 The electrical system(s) associated with the emissions abatement plant is to meet the requirements of the *Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquid Chemicals in Bulk* and/or the *Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquefied Gases in Bulk*, as applicable.

13.9.4 The control system(s) associated with the emissions abatement plant is to meet the requirements of the *Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquid Chemicals in Bulk* and/or the *Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquefied Gases in Bulk*, as applicable.

13.9.5 Electrical equipment for use in explosive gas atmospheres

(a) Lighting fittings are to be of a certified-safe type and arranged on at least two independent final branch circuits. Switches and protective devices are to interrupt all lines or phases and are to be located outside the space.

(b) Where electric motors driving ventilation fans are located within the spaces, within ventilation ducts, or within three metres of ventilation openings, they are to be of a certified-safe type.

(c) Monitoring control and alarm systems which are required to operate under conditions of ammonia leakage are to be of a certified-safe type.

(d) Electrical equipment which is not of a certified-safe type is to de-energise automatically if the ammonia concentration within the space exceeds 1,0 per cent by volume.

13.9.6 All compressors are to be provided with the following instrumentation and automatic shutdowns:

- Indication of suction pressure (saturated temperature), including intermediate stage, when applicable;
- Indication of discharge pressure (saturated temperature), including intermediate stage, when applicable;
- Indication of lubricating oil pressure;
- Indication of cumulative running hours (screw compressors);
- Automatic shutdown in the event of low lubricating oil pressure;
- Automatic shutdown in the event of high discharge pressure;
- Automatic shutdown in the event of low suction pressure.

13.9.7 The automatic safety equipment is to be designed to fail safe and the arrangements are to be such that the compressors can be operated manually with the equipment out of action, in accordance with the relevant requirements of *Pt 6, Ch 1 Control Engineering Systems*.

13.9.8 For installations greater than 25 kW the following instrumentation, additional to that required by *Pt 5, Ch 24, 13.9 Electrical, control and safety systems 13.9.6*, is to be provided:

- Indication of lubricating oil temperature;
- Indication of cooling water outlet temperature;
- Indication of cumulative running hours (reciprocating compressors);
- Indication of suction and discharge temperatures.

13.9.9 Where the refrigerating system is fitted with automatic or remote controls, so that under normal operating conditions no manual intervention by the Operators is required, it is to be provided with the alarms required by *Pt 5, Ch 24, 13.9 Electrical, control and safety systems 13.9.10* and *Pt 5, Ch 24, 13.9 Electrical, control and safety systems 13.9.11*, and in accordance with the relevant requirements of *Pt 6, Ch 1 Control Engineering Systems*.

13.9.10 Alarms are to be initiated in the event of the following compressor fault conditions:

- High discharge pressure;
- Low suction pressure;
- Low oil pressure;
- High discharge temperature;
- High oil temperature;
- Motor shutdown.

13.9.11 Alarms are also to be initiated in the event of the following fault conditions:

- Failure of condenser cooling water pumps;
- High condenser cooling water outlet temperature;
- Failure of air cooler fans;
- High and low refrigerated air delivery temperatures;
- High secondary refrigerant temperatures;
- Failure of secondary refrigerant pump;
- Failure of air refreshing fans;
- Low level in secondary refrigerant header tank.

13.9.12 Temperature sensors are to be of a type which has been accepted by LR. The number of sensors and their locations are to be such as to give a true measurement of the temperatures within the refrigerated spaces and of the cooler delivery and return air temperatures.

13.9.13 Refrigerant detection systems

(a) A fixed refrigerant detection system is to be provided in the refrigerating machinery compartment or space, the discharge pipes from pressure relief valves, the ventilation outlet ducts, and the cargo chambers, where appropriate.

(b) The system is to comply with the requirements of *Pt 6, Ch 1 Control Engineering Systems* and, as a minimum requirement, the system is to activate at a low-level concentration to give warning of refrigerant leaks, and a high-level concentration corresponding to the refrigerant's safe occupational level.

(c) Detection equipment is to be so designed that it may be readily tested and calibrated, and failure of the equipment is to initiate an alarm.

(d) The locations of the detectors are to be determined relative to the layouts of the individual compartments and machinery spaces, and are to be indicated on the plan submission.

(e) For carbon dioxide systems, spaces such as machinery rooms, storage compartments, production areas on fishing vessels and valve stations, where leakage may occur, are to be fitted with detectors. Welded pipelines passing through passageways or access ducts are not considered possible leakage areas.

(f) Audible and visual alarms are to be activated, located both inside and outside the affected space. The alarms are to be readily identifiable and are to be visible and audible in all locations within the space housing the refrigeration equipment.

(g) Ammonia vapour detection and alarm equipment:

- A fixed detector system for ammonia is to comply with the requirements contained in *Pt 5, Ch 24, 13.9 Electrical, control and safety systems 13.9.13 (g)*.
- The locations of the detectors are to be determined relative to the layouts of the individual spaces and are to be indicated on the plan submission required by *Pt 5, Ch 24, 13.3 Information to be submitted 13.3.2*.
- Ammonia vapour detectors are to be provided in the refrigeration machinery compartment, associated accessways, the exhaust duct, the ammonia store room and the discharge pipes from pressure relief valves.
- Sufficient detectors are to be provided to monitor the total areas of the above spaces.
- For vapour detection in relief valve discharge pipes, *see Pt 5, Ch 24, 13.7 Refrigeration plant, pipes, valves and fittings 13.7.13 (d)*.
- Details of the refrigerant detector set points and operational philosophy are to be submitted for consideration.

13.9.14 For the detection of gas and vapours, a gas detection system is to be fitted that is to activate at a concentration corresponding to the substance safe occupational level. The locations of the detectors are to be determined relative to the layouts of the individual spaces and are to be indicated on the plan submission required by *Pt 5, Ch 24, 3.3 Chemical substances 3.3.9*. Where gas detection equipment is not appropriate, e.g. for substances not emitting gases or vapours, alternative proposals are to be submitted to ensure the safety of persons from exposure to such substances.

13.9.15 Remote access to the system shall only be possible after intervention and manual action of the crew.

13.9.16 The storage tank(s) is to be fitted with independent high and high-high level alarms.

13.9.17 Emergency shutdown (ESD) arrangements are to meet the requirements of *Ch 18 Operating Requirements* of the *Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquefied Gases in Bulk*, as applicable.

13.9.18 A process emergency shutdown system shall be fitted to stop process flow in the event of an emergency, either internally within the ship, or during process transfer to ship or shore. The design of the ESD system shall avoid the potential generation of surge pressures within process transfer pipe work.

13.9.19 Auxiliary systems for conditioning the process that use toxic or flammable liquids or vapours shall be treated as process systems for the purposes of ESD. Indirect refrigeration systems using an inert medium, such as nitrogen, need not be included in the ESD function.

13.9.20 The ESD system shall be activated by the manual and automatic initiations. Any additional initiations shall only be included in the ESD system if it can be shown that their inclusion does not reduce the integrity and reliability of the system overall.

13.9.21 The control and monitoring system of the compressed and liquefied CO_2 portable storage tanks is to be integrated in the ship's control and monitoring system. The safety system shall be integrated in the ship's safety system.

13.9.22 Suitable control, alarm, monitoring and shutdown systems shall be provided to ensure safe and reliable operation.

13.10 Fire protection and extinction

13.10.1 Fixed gas detection suitable for all spaces and areas concerned shall be arranged.

13.10.2 Fire detection, protection and extinction measures appropriate to the hazards concerned shall be provided.

13.10.3 The fire control plan is to include the items specified.

13.11 Personal protection

13.11.1 The extent of the required personal protection is to be satisfied based on MSDS in consideration with risk-based studies, in accordance with the requirements of, and to the satisfaction of, the Administration.

13.11.2 One or more suitably marked decontamination showers and eyewash stations shall be available on deck, taking into account the size and layout of the ship in consideration with risk-based studies.

13.11.3 Amine solvent (ethanolamine solution)

(a) Suitably marked decontamination showers and an eyewash shall be available on deck in convenient locations, taking into account the size and layout of the ship and installation arrangements. The showers and eyewash shall be operable in all ambient conditions.

13.11.4 The fire control plan is to include the items specified.

13.12 Manufacture, certification, workmanship and testing

13.12.1 Manufacturing, testing and integration of piping and fittings are to be in accordance with the following Parts of the

- *Pt 5, Ch 12 Piping Design Requirements*;
- *Pt 5, Ch 13 Ship Piping Systems*;
- *Pt 5, Ch 14 Machinery Piping Systems*; or
- *Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquid Chemicals in Bulk*; or
- *Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquefied Gases in Bulk*, as applicable.

13.12.2 In addition to the requirements given in *Pt 5, Ch 24, 5 Hull construction* for the ship integration, the scrubber tower materials are to satisfy *Pt 5, Ch 24, 4.1 General 4.1.1* and welding is to be in accordance with *Ch 12 Welding Qualifications* and *Ch 13 Requirements for Welded Construction* of the *Rules for the Manufacture, Testing and Certification of Materials*.

13.12.3 Piping intended for chemicals is to be joined by welding and composed of Class II piping systems. *See IBC Code, Sections 5.2 to 5.6* and *LR6.3(b)*. Materials for piping systems are to comply with the requirements of *Pt 5, Ch 12 Piping Design Requirements* of the *Rules and Regulations for the Classification of Ships* for Class II systems. Materials for open ended and vent piping may be to Class III requirements. *See also Ch 1, 6.1 Materials of construction and welding.*

13.12.4 Where it is proposed to use components (e.g. compressors, condensers, oil separators) which have valid LR Type Approval or General Approval Certificates, the types and model numbers of the components are to be stated. Plans of components that have been so approved need not be re-submitted.

13.12.5 Commissioning, trials and maintenance of emissions abatement plant shall satisfy goals in terms of safety, availability and reliability.

13.12.6 Testing procedures during installation and commissioning trials are to be submitted.

13.12.7 The materials used in the construction of the CCS (carbon capture and storage) unit are to be manufactured and tested in accordance with the requirements of the *Rules for the Manufacture, Testing and Certification of Materials*.

(a) Where alternative design and material specifications are proposed, that are not listed in Rules for materials, then the framework of MSC.1/Circ.1622: Guidelines For The Acceptance Of Alternative Metallic Materials For Cryogenic Service In Ships Carrying Liquefied Gases In Bulk And Ships Using Gases Or Other Low-Flashpoint Fuels should be followed, together with LR Guidance Notes for Special Consideration Process for Materials Applications.

13.12.8 Pressure testing at manufacturers' works for refrigeration plant, pipes, valves and fittings:

(a) Components intended for use with a primary refrigerant are to be subject to strength and leak pressure tests as detailed in *Pt 6, Ch 3, 4.21 Pressure testing at manufacturers works, Table 3.4.2 Test Pressure*

(b) Component strength pressure tests are to be hydraulic, or where suitable safety measures are taken, may be pneumatic. The latter are to be carried out with a suitable dry inert gas.

(c) Component leakage pressure tests are to be carried out only after completion of satisfactory strength pressure tests. Pneumatic pressure is to be applied using a suitable dry inert gas.

(d) Components for use with a secondary refrigerant or cooling water are to be hydraulically tested to 1,5 times the design pressure, but in no case less than 0,35 MPa g.

13.12.9 Pressure test after installation on board ship for refrigeration plant, pipes, valves and fittings:

(a) For primary refrigerant piping welded in place, strength pressure tests with a suitable fluid and with welds of a suitable medium are to be carried out at a test pressure of 1,5*p*.

(b) Pneumatic pressure tests are to be carried out using a suitable inert gas. All pneumatic tests are potentially dangerous and due precautions are to be observed.

(c) Where pneumatic tests are prohibited by relevant authorities, the tests required by *Pt 5, Ch 24, 13.12 Manufacture, certification, workmanship and testing 13.12.9 (b)* may be omitted provided that non-destructive tests by ultrasonic or radiographic methods are carried out with satisfactory results on the entire circumference of all butt welds not tested in accordance with *Pt 5, Ch 24,*

13.7 Refrigeration plant, pipes, valves and fittings 13.7.10 (c). Where ultrasonic tests have been carried out, the acceptance criteria shall be in accordance with *Table 13.2.7 Acceptance criteria for ultrasonic and phased array testing* in *Ch 13, 2 Specific requirements for ship hull structure and machinery* of the *Rules for the Manufacture, Testing and Certification of Materials*. Where radiographic tests have been carried out, the acceptance criteria shall be in accordance with *Table 13.2.6 Acceptance criteria for radiographic testing* in *Ch 13, 2 Specific requirements for ship hull structure and machinery* of the *Rules for the Manufacture, Testing and Certification of Materials*. In all cases, the manufacturer shall provide a written report in accordance with the requirements of *Ch 1, 5 Non-Destructive Examination* of the *Rules for the Manufacture, Testing and Certification of Materials*.

(d) After completion of the test required by *Pt 5, Ch 24, 13.12 Manufacture, certification, workmanship and testing 13.12.9 (a)*, *Pt 5, Ch 24, 13.12 Manufacture, certification, workmanship and testing 13.12.9 (b)* or *Pt 5, Ch 24, 13.12 Manufacture, certification, workmanship and testing 13.12.9 (c)*, a leak pressure test is to be carried out using a suitable inert gas at a pressure equal to the design pressure, in the presence of the Surveyor.

(e) Secondary refrigerant piping welded in place is to be hydraulically tested to 1,5 times the design pressure, but in no case less than 0,35 MPa g.

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